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**Reverse Logistics at the Commander, Naval Surface Forces Real-time &
Reutilization Asset Management (R-RAM) San Diego Warehouse**

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December 2008**

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FORCES REAL-TIME & REUTILIZATION ASSET MANAGEMENT
(R-RAM) SAN DIEGO WAREHOUSE**

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REVERSE LOGISTICS AT THE COMMANDER, NAVAL SURFACE FORCES REAL-TIME & REUTILIZATION ASSET MANAGEMENT (R-RAM) SAN DIEGO WAREHOUSE

ABSTRACT

The purpose of this MBA project is to evaluate and assess the inventory management database at the Commander, Naval Surface Forces (CNSF) Real-time Reutilization Asset Management (R-RAM) San Diego warehouse. CNSF spends approximately \$4 million annually for contractor support to operate the R-RAM warehouses for the Atlantic and Pacific Surface Fleets, and in return receives cost-avoidance for spares issued from the warehouses. The warehouses contain A-condition spare parts that were offloaded from decommissioned ships, as well as excess inventory from afloat units. Spare parts in the R-RAM warehouses were procured either by using initial outfitting allowance or by Operations and Maintenance (O & M) funds. The spare part is issued free to the requesting ship. The R-RAM inventory is visible to customers through the Global Distance Support Center and various databases. The goals of this study of the R-RAM inventory management database are to determine ways to increase throughput while simultaneously reducing inventory and operating expense, reduce inventory footprint by identifying “dead” stock and obsolete spares, recommend a stocking policy, and develop recommendations for current and future operations.

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I. INTRODUCTION

A. BACKGROUND

The purpose of this MBA project is to evaluate and assess the inventory management at the Commander, Naval Surface Forces (CNSF) Real-time Reutilization Asset Management (R-RAM) San Diego warehouse. CNSF spends approximately \$4 million annually for contractor support to operate the R-RAM warehouses for the Atlantic and Pacific Surface Fleets. The warehouses contain A-condition spare parts that were offloaded from decommissioned ships, as well as excess inventory from afloat units. Spare parts in the R-RAM warehouses were paid either by using initial outfitting allowance or by Operations and Maintenance (O & M) funds. Since the spare parts have already been paid by these funds, the spare parts issued from the R-RAM inventory are issued free of charge to the requesting ships. The R-RAM inventory is visible to customers through the Global Distance Support Center and various databases.

The Real-time Reutilization Asset Management (R-RAM) provides for online and real-time Total Asset Visibility (TAV) of excess material. It efficiently captures demand data for excess material that resides in the 16 R-RAM warehouses worldwide. By increasing the asset visibility of available material, R-RAM provides a mechanism for automated requisitioning of excess spare parts and ensures proper replenishment decisions are made by inventory managers when considering additional available inventories within the R-RAM warehouses.

The 16¹ R-RAM warehouses worldwide are operated by contractors and funded independently by the cognizant asset holders that funded the material from their Operational and Maintenance (O & M) budgets. Different contractors and contract vehicles run each warehouse. The absence of a singular global contract makes it difficult

¹ The 16 R-RAM warehouses are at Commander, Naval Surface Forces, San Diego, CA; Mid-Atlantic Regional Maintenance Center, Portsmouth, VA; Minesweepers, Ingleside, TX; Submarine Shore Spares, Cheatham Annex, VA; NAVAIR R-RAM, North Island, CA; NAVAIR SOM, Orange Park, FL; Naval Sea Detachment, Auburn, WA; SUBPAC, Pearl Harbor, HI; SRF, Sasebo, Japan; SRF, Yokosuka, Japan; Ship Repair Unit, Bahrain; Military Sealift Command, Chesapeake, VA; SUPSHIP SURFLANT RRM, Portsmouth, VA; Landing Craft Air Cushion Squadron 4, Panama City, FL; Landing Craft Air Cushion Squadron 4, Little Creek, VA; and Naval Air Station, Patuxent River, MD.

to streamline warehouse operations for all sites, gain operational efficiency, pool resources and reduce operating costs. The inventories from each warehouse are centrally-managed at the Naval Inventory Control Point (NAVICP) using the LAWSON inventory management database. All requisitions originating from the Fleet, as well as Naval Shore Facilities, will be issued from the R-RAM inventory prior to being filled by the Navy Supply System or the Defense Logistics Agency (DLA).

Before continuing with R-RAM's current status, it is important to briefly discuss the driving force behind R-RAM and how the program evolved. There has always been an issue of what the Navy, as a whole, should do with excess offloaded material². Mark O'Brien, a NAVSUP contractor working within R-RAM, provides an insight on the history of R-RAM and Total Asset Visibility. In the early 1990s, the various Type Commander's (TYCOM)³ and System Commands (SYSCOM)⁴ all supported their own excess spare parts. Since the TYCOMs and SYSCOMs used their own Operational and Maintenance (O&M) funding to procure onboard spare parts, they were reluctant to give up their "gold piles"⁵ (2008, May 21). This excess material was not centrally located ashore nor was it located in storerooms on operational units afloat. While excess material may have been visible to units within their own TYCOM, there was limited visibility between TYCOMs. A lack of TAV Navy-wide was considered the major problem arising out of these "gold piles" (2008, May 21). In some cases, an artificial shortage existed even though the parts were available. All of the "gold piles" made it difficult for the Navy Item Managers to accurately predict demand and inventory level, which forced them, at times, to engage in speculative demand forecasting. Inaccurate demand forecasting resulted in an increase of Not- in-Stock (NIS) requisitions, which caused

² Excess material is considered to be any spare part in inventory that has not been issued in a two-year period.

³ Each Naval platform has a TYCOM. The Naval Surface Force is SURFOR. The Naval Air Force is AIRFOR. The Naval Submarine Force is SUBFOR. The TYCOMs are responsible for staffing, training, and equipping their respective force.

⁴ The Naval System Commands are the Naval Sea System Command, Naval Air System Command, and Naval Supply System Command. The System Commands outfit units with new weapons systems and spare parts support.

⁵ "Gold pile" also refers to spare parts because owners would hoard the spare parts like gold.

longer Average Customer Wait Time (ACWT)⁶. Not-in-stock items force item managers into reactive forecasting, which often leads to over buying. In addition to obvious additional inventory holding costs, these “gold piles” resulted in unnecessary expenditures of precious and scarce O&M funds for items already purchased and in storage at a warehouse or aboard ships.

Some of those inventories were reflected in Consolidated Residual Asset Management Screening Information (CRAMSI)⁷ system, which was managed by Naval Sea Logistics Center (NAVSEALOGCEN) (O’Brien, 2008, May 21). The CRAMSI systems allowed users to access the available material in the excess inventory. The problem with CRAMSI was that it was only as good as the data that was input into the system. It was not a Real-time system (2008, May 21).

The original RAM (one "R") was created at the Ship’s Parts Control Center (SPCC), which is now NAVICP-Mechanicsburg (2008, May 21). SPCC volunteered to build a system to manage the TYCOMs and SYSCOMs excess material to make it visible to and accessible by the supply system. The original RAM was instituted to appease the auditors wondering how the TYCOMs and SYSCOMs accounted for excess spare parts (2008, May 21). SPCC only provided the computer system. As it operates today, the local management of the excess material was under the control of the TYCOMs and SYSCOMs, who originally procured the material through their O & M budget (2008, May 21).

In 1995, NAVSUP implemented the Uniformed Automated Data Processing System (UADPS). The RAM inventory was visible in the Virtual Master Stock Inventory Record (VMSIR), which was the same system used at the Fleet and Industrial Supply Centers (FISC). The FISCs are the entry point for all requisitions into the Navy

⁶ ACWT is a CNSF metric that measures the time it takes to complete the order fulfillment process (i.e., the time it takes between when the part is ordered to the time it is received).

⁷ CRAMSI is a data feed from individual units displaying what material the unit has on hand at the time of data download.

Supply System. In 1998, NAVSUP introduced the Central Point of Entry Network (CPEN). The requisitions processed through CPEN were also able to access RAM (O'Brien, 2008, May 21).

NAVSUP and NAVICP Mechanicsburg transitioned from the original RAM to R-RAM (Real-time Reutilization Asset Management) in December 2000 when the system was converted from UADPS to a Commercial-of-the-Shelf (COTS) product from a company called Lawson Insight (2008, May 21). Implementation of the web-enabled, R-RAM Lawson TAV program was a step in the right direction in improving logistics readiness and reducing unnecessary O&M expenditures. It has resulted in better requirements forecasting, asset visibility, and material distribution. Furthermore, the initiative resulted in a timely and accurate location of critical repair parts. Visibility of materials in the warehouses and excess parts onboard ships have resulted in lower NIS requisitions, which in turn aided the Navy inventory managers in accurately maintaining inventory level. They have gone from speculative and reactive forecasting to a more efficient real-time demand inventory policy.

The team in NAVICP- Mechanicsburg was transferred to NAVSISA in 2003 as part of Navy Transformation (O'Brien, 2008, May 21). In addition to CPEN/VMSIR, current R-RAM interfaces with NAVICP (Flashpoint and IM Toolkit), One Touch Supply, and NAVSEALOGCENs Outfitting Requisition Control and Accounting System (ORCAS) (2008, May 21).

The Commander, Naval Surface Forces spends approximately \$4 million annually for contractor support to operate the Real-time Reutilization Asset Management (R-RAM) warehouses for the Atlantic and Pacific Surface Fleets. The warehouses contain A-condition⁸ spare parts that, by the use of reverse logistics, were offloaded from decommissioned ships and include excess inventory from afloat units. Upon commissioning, Navy ships are outfitted with an initial allowance of spare parts and receive replacement parts for those that were used throughout its lifecycle. The spare parts are listed as onboard repair parts under a ship's Coordinated Shipboard Allowance

⁸ "A" condition spare parts are in unopened and never-been-issued state. Our major assumption is that all parts in RRAM are "A" condition.

List (COSAL). COSALs specify the range and depth of spare parts ships are required to carry onboard. Even with a COSAL specified inventory level, excess inventories often occur due to inaccurate re-orders or by the periodic removal/update of weapon systems throughout the lifecycle of the ship. If a surface ship needs a part, the requisition is screened at the R-RAM warehouse before entering the Navy Supply System for issue. If the part is available in the R-RAM warehouse, it is then sent to the requesting ship as a free issue. Figure 1 describes the requisition process. When a requisition leaves the ship, the O & M funds are obligated for that requisition. The Fleet and Industrial Supply Center (FISC) automatically check the R-RAM database for availability. If the part is available at the R-RAM warehouse, it is issued and a BN⁹ status is sent to the requisitioning ship informing the crew of the free issue and notifying them to de-obligate the funds for other priorities. If, on the other hand, the part is not available at the R-RAM warehouse, the requisition proceeds through the Navy Supply System order fulfillment process.

Del Rey System and Technology Inc., a subcontractor for Science Applications International Corporation (SAIC), is the current contractor under contract number N00244-07-C-0009. It provides logistic services on Pacific Fleet ships and shore stations by providing technical support services to CNSF. Specifically, it assists in the management of afloat inventories and related logistics support to improve the level of fleet readiness.

⁹ BN. Naval Supply Systems Command Publication (1997). NAVSUP P-485 Vol II Appendix 2 Naval Supply Procedures. A financial code that identifies a requisition as a free-issue.

Requisition Process

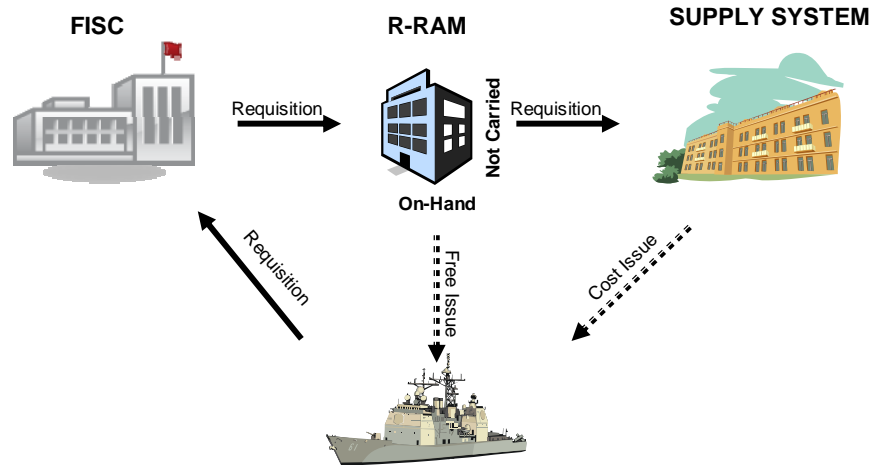


Figure 1. Requisition Process

B. PURPOSE

The purpose of the project is to analyze current inventory to determine ways to increase throughput, determine ways to decrease inventory and operating expense, and provide CNSF with recommendations.

C. RESEARCH QUESTION

The primary research questions are: (1) What percentage of the San Diego R-RAM warehouse current inventory is dead stock? (2) What available alternatives could increase the throughput at the San Diego R-RAM warehouse? (3) What are the costs and benefits to CNSF operating the warehouses?

In order to answer these research questions we will perform an in-depth analysis of the current R-RAM inventory to determine excess material, “dead” stock, and obsolete parts. This inventory had grown to a value of \$289 million at the beginning of fiscal year 2008. This was largely due to the increase in ship decommissioning and periodic TYCOM-directed excess offloads.

We believe that our inventory management control recommendations can easily be replicated at the remaining 15 R-RAM warehouses. As CNSF redefines its roles in support of the surface warfare enterprise, it is looking into what constitutes its core competencies. This report, along with a NPS thesis looking into activity-based costing analysis of the warehouse operating expense (MBA report—Russo et al.), will aid CNSF N41 in its decision-making process with respect to the idea of divesting the R-RAM warehouses.

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II. LITERATURE REVIEW

A. OVERVIEW

Reverse Logistics is a relatively new name for an old practice in the military. This is vividly supported by the historical writings of Henry J. Aten, who wrote *History of the 85th Regiment, Illinois Volunteer Infantry*, in which he describes the retrograde operations of General William T. Sherman's army: "The ammunition trains were relieved of their now useless contents, and the wagons were loaded with provisions and forage, and by the evening of the 30th, preparations for a peaceful homeward march had been completed" (1901, p. 308). This provides an idea of the disposal operations undertaken by General Sherman to dispose of useless supplies that posed great burden on their return march. Constrained by the lack of adequate means of transportation, General Sherman's ability to prioritize the loading of critical food supplies instead of useless ammunitions proved critical in their successful retrograde operation. Major Johnny W. Sokolowsky in his thesis *Role of the Union Logistics in the Carolina Campaign of 1865* also discovered that the Carolina Campaign emphasizes the importance of prioritization and integration between the logistic and operational planner in order to negate or overcome transportation shortfall. He further concluded that the success of the campaign is attributed partly to Sherman's clear understanding of the importance of logistics (p. 111). A brilliant military logistician once said that tactics win battles but logistics wins wars.

On the other hand, the Carolina Campaign also highlighted the inability of General Sherman to capture the remaining economic value of the disposed ammunitions. This could be attributed to the lack of purposeful planning to save precious dollars through the recovery of unused ammunitions. Value recovery is important because it could be a primary source of inventory replenishment, especially for expensive supplies (Diener, Pelz, Lackey, Blake, & Vaidyanathan, 2004, p. 1). It is on this note that the importance of reverse logistics comes into play.

B. REVERSE LOGISTICS DEFINED

Despite the fact that Reverse Logistics problems existed during the Civil War years, little research had been devoted to it. This could probably explain why there is no generally accepted definition currently being used in the military, business and academe. One of the earliest descriptions of Reverse Logistics was given by Lambert and Stock in 1981. They described it as “going the wrong way on a one-way street because the great majority of product shipments flow in one direction” (Rogers & Tibben-Lembke, 2001, p. 1). A similar definition was given by Murphy in 1986 and by Murphy and Poist in 1989. They defined Reverse Logistics as the “movement of goods from a consumer towards a producer in a channel of distribution” (1989, p. 1). These earlier definitions have a limited scope because they focus only on the movement of material from the customer toward the producer.

However, the meaning of Reverse Logistics has evolved over time. In 1992, The Council of Logistics Management (CLM) introduced Reverse Logistics as the term often used to refer to the role of logistics in recycling, waste disposal, and management of hazardous materials; a broader perspective includes all issues relating to logistics activities carried out in source reduction, recycling, substitution, reuse of materials and disposal (Stock, 1992, p. 25). In 1998, Carter and Ellram stated that Reverse Logistics is a process whereby companies can become more environmentally efficient through recycling, reusing, and reducing the amount of materials used. (Carter, 1998, p. 1). The most recent definition was given by Rogers and Tibben-Lembke, who stated that:

Reverse Logistics is the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information from the point of consumption to the point of origin for the purpose of recapturing value or proper disposal. (Rogers & Tibben-Lembke, 1999, p. 2)

The meaning of Reverse Logistics can also vary depending on what perspective it is being used. From a business logistics perspective, Reverse Logistics refers to the role of logistics in product returns, source reduction, recycling, materials substitution, reuse of materials, waste disposal, and refurbishing, repair and remanufacturing. From an engineering logistics perspective, it is referred to as Reverse Logistics

Management(RLM) and is a systematic business model that applies best logistics engineering and management methodologies across the enterprise in order to profitably close the loop on the supply chain (Stock, 1998, pp. 20-21).

The changing meaning of Reverse Logistics is due mainly to the developing nature of this discipline. However, there is an obvious overlap among the presented definition even though none of them is exactly the same. Three common aspects of Reverse Logistics exist: (1) direction of flow of goods; (2) the goods flowing are products of which an original use has been completed or has become impossible; and (3) overwhelming focus on the receiving party (Fleischmann, 2001, p. 6).

C. REVERSE LOGISTICS IN THE COMMERCIAL WORLD

No documented history points to the exact birth of Reverse Logistics in U.S business industry. However, according to Jeffrey De Vore, Reverse Logistics surfaced as a legitimate business practice in the late 1980s (2004, p. 13). Fleischmann (2001) offered four motives that drive businesses to engage in Reverse Logistics: economic, marketing, legislative and asset protection (pp. 17-18).

Srivastava (2008) in his published worked entitled “Network Design for Reverse Logistics” also shared this view. However, Srivastava made more emphasis on the influence of environmental management orientation of supply chains (p. 535).

At present, Reverse Logistics is a multi-million dollar industry. According to Linda S. Beltran (2002) in her paper entitled “Reverse Logistics: Current Trends and Practices,” Reverse Logistics accounts for 4% of all logistics costs: an estimated 10.7% of the US economy (p. 4). This makes Reverse Logistics a half percent of the total US Gross Domestic Product. In a 1997 study made by Rogers and Tibben-Lembke (2002), Reverse Logistics costs are estimated to be \$35 billion (p. 275).

In the white paper authored by Dr. James Stock in 1998, he highlighted the benefits achieved by companies practicing reverse logistics:

In 1996, Baxter's environmental initiatives saved the company \$11 million; cost avoidance efforts (e.g., raw materials, production processes, disposal costs, packaging) initiated during 1989-1996 saved the company \$94 million.

In 1990, Toyota Motor, at its manufacturing plant in Kentucky, developed a packaging standard for its supplier that was based on the use of recyclable, recycled, and reusable packaging. Annual savings were \$3.6 million.

Herman Miller Inc. has saved more than \$1 million annually due, in part, to the use of reusable containers or carton-less furniture packaging.

In 1992, Deere and Company instituted a reusable packaging system that resulted in packaging savings of \$1.7 million and an 18% reduction in inventory (Stock, 1998).

The above-mentioned Reverse Logistics activities have consistently shown a huge economic incentive in such endeavor. Moreover, successful Reverse Logistics activity provides a great source of competitive advantage to the firm that is not easily replicable by the others (Amni, Retszaff-Robert, & Bienstock, 2005, p. 367).

D. REVERSE LOGISTICS IN THE DEFENSE DEPARTMENT

The Defense Reutilization and Marketing Service spearhead the Reverse Logistics activity in the Defense Department. Its mission is to provide the DoD's best value services and deliver excellent performance to its customers for the reuse, transfer, donation, sale or disposal of excess/surplus property (Defense Logistics Agency, 2008). It was established in 1972, but the services it provides date back to the end of World War II when there were huge amounts of military surplus property that needed to be disposed of. During that time, the return on their sales was said to be so small that the units created to reduce the military stockpile were soon disbanded. In 1949, the Federal Property and Administration Services Act delegated the administration of surplus property to executive agencies, allowing the DoD to control its surplus property. In 1972, the McClellan Report recommended the centralization of disposal for better accountability. Consequently, the Defense Property Disposal Service (DPDS), the precursor of DRMS, was established.

At present, DRMS is the lead agency that implements the DoD Resource Recovery and Recycling Program (RRRP). In FY2006, \$1.9 billion worth of property was reutilized, which contributes to the DoD's effort of attaining sound financial stewardship.

Although DRMS is the lead agency in the reverse logistics activity of the DoD, the different services have their own varying programs that fall under the sphere of reverse logistics. Limited published documents talk about specific reverse logistics programs in the various services. Unlike in the research made by Dr. Stock, in which he studied a number of commercial reverse logistics practices by various firms, there is no such authoritative paper that has studied the different military units. Among the limited works, Major Jeffrey W. De Vore USAF, contributed a study on Reverse Logistics operations of the Air Mobility Command of the US Air Force. His work greatly enhanced understanding the inadequacies of the present Reverse Logistics Operations of Air Mobility Command, more particularly in its mission to conduct retrograde operations. Likewise, the study made by De Vore concretely describes and analyzes the major problems that exist within AMC's reverse channel using the Dawe's and Stock's Framework. Although no effort was devoted in validating the stated recommendations in the study, the work continues to be a very useful guide in implementing similar Reverse Logistics activities.

A related study was made for the US Army by the group of Deiner, Pelz, Lackey, Black, and Vaidyanathan (2004) at RAND. The research was triggered by the Army's need to transform into a more mobile force the simultaneously necessitates the reduction of logistics footprint while extending its reach (p. 3). The central focus of the two reports assesses the present retrograde operations and provides ways to improve them. Deiner, et al., (2004) used the framework developed by Rogers and Tibben-Lembke in structuring the existing Reverse Logistics operations and further incorporated the Define-Measure-Improve (DMI) methodology to achieve continuous process improvement. The study greatly contributed in the developing a quantitative approach to Reverse Logistics by using metrics that will be valuable in conducting future related studies. The study also supported the conclusion made by Ferguson and Browne (2002) that there is a need to

have an excellent information flow as the product moves in the reverse pipeline (p. 536). Diener et al. (2004) contends that there must also be total asset visibility in Reverse Logistics in the same manner that it is needed in the forward channel.

E. REVERSE LOGISTICS OPERATIONS IN THE NAVY

A study entitled “A Review of Reverse Logistics and Depot Level Repairable” conducted by Stevenson, Toussaint and Edwards (2005) highlighted the importance of using an electronic information system to attain total asset visibility. The use of the Electronic Retrograde Management System (ERMS), a web-based program, is a key enabler in improving the throughput in the Reverse Logistics pipeline by providing rapid turn-in credit, reducing carcass tracking, and providing shore installation with instant in-transit visibility (p. 19).

The different studies mentioned in this chapter clearly validates that there are varied ways to engage and benefit from Reverse Logistics. The commercial sector can reap considerable cost savings and customer satisfaction by promoting a closed-loop supply chain. On the other hand, the Defense Department can achieve significant cost avoidance by continuously improving the transportation and cycle time of product repair or refurbishment.

F. INVENTORY MANAGEMENT

Inventory is the stock of any item or resource used in an organization. In the service sector, it generally refers to tangible goods to be sold and the supplies necessary to administer the service. An inventory system is the set of policies and controls that monitor levels of inventory: what levels should be maintained, when stock should be replenished, and how large orders should be (Apte et al., 2006, p. 135).

According to Apte et al. (2006), there are three main reasons why service firms maintain a supply of inventory. They are as follows:

1. *To maintain independence of operations.* In order to prevent disruption of operations due to unavailability of needed supplies, firms generally maintain a certain level of cushion to offset the uncertainty of resupply arrival. This allows greater flexibility to the firm in its operations.

2. *To meet variation in product demand.* In theory, the demand for a certain product or supply can be computed, thus it is possible to stock the exact demand for the product or supply. However, reality dictates that demand for the product is not completely known, and a safety stock or buffer stock must be maintained to absorb the variation.

3. *To take advantage of economic purchase order size.* Placing an order entails ordering costs like labor, phone calls, typing, postage, etc. It is therefore more appropriate to order in bulk to minimize frequent orders, which minimizes ordering costs. Likewise, shipping costs tend to decrease when there is large order, due primarily to the fact that the per-unit cost is distributed to a larger size or number of unit or item (p. 135).

In the process of maintaining inventory, several costs are incurred by the firm. It is in managing these costs vis-à-vis that the possible stock-out cost that is central to the effective and efficient management of inventory. Chopra and Meindl (2001) have identified such costs:

1. *Inventory Holding Cost.* It is estimated as the sum of the following major components, not all of which are applicable to every type of situation. Holding cost is usually estimated as a percentage of the cost of a product.

Cost of Capital. This cost is frequently the most important component of holding cost. It is the opportunity cost of capital and is correctly computed by evaluating the weighted average cost of capital (WACC). This cost takes into account the return demanded on the firm's equity and the amount the firm must pay on its debt. These are weighted by the amount of debt and equity financing the firm has. The formula for the WACC is as follows:

$$WACC = \frac{E}{D + E} (R_f + \beta * MRP) + \frac{D}{D + E} R_b (1 - t)$$

Where

- E=amount of equity
- D=amount of debt
- R_f=risk-free rate of return (which is usually in the mid-single digits)
- B=the firm's beta
- MRP=market risk premium (which is around the high single digits)
- R_b=rate at which the firm can borrow money (related to its debt rating)
- t=tax rate

Obsolescence (or spoilage) cost estimates the rate at which the value of the product being stored drops either because the market value of that product drops or because the product quality deteriorates. The drop rate of value depends on the product being stored. Inventory of freshly baked bread that can sell for only a day has a high obsolescence rate. On the other hand, automobile tires can be stored for a considerable period without considerable loss to value.

Handling Cost. This cost includes the receiving and storage costs that vary with the volume of the product received. Volume-independent costs that vary with the number of orders should be included in the order cost. Volume-dependent costs are generally small, and often the real cost does not change if volume varies within a range. If the volume is within this range (e.g., the range of inventory a crew of four people can unload per period), incremental handling cost added to the holding cost is zero. However, if incremental handling cost is incurred, then handling cost associated with this additional inventory should be included in the holding cost.

Occupancy Cost. It reflects the incremental change in space cost due to changing cycle inventory. If the firm is being charged based on the actual number of units held in storage, the direct occupancy cost results. However, firms often lease or purchase a fixed amount of space. As long as a marginal change in cycle inventory does not change the space requirements, the occupancy cost should be considered zero.

Occupancy, or space costs, often takes the form of a step function with a sudden increase in cost when capacity is fully utilized and new space must be acquired.

Miscellaneous Cost. It is composed of other relatively small costs such as theft, security, damage, tax, and additional insurance charges that may be incurred. It is important to estimate the incremental change in these costs on changing cycle inventory.

2. Order Cost. It includes all incremental costs associated with placing or receiving an extra order that are incurred regardless of the size of the order. Components of order cost include the following:

Buyer Time. This cost is the incremental time of the buyer placing the extra order and should be included only if the buyer is utilized fully. The incremental cost of getting an idle buyer to place an order is zero and does not add to order cost. Electronic ordering can significantly reduce the buyer time to place an order by making order placement simpler and in some cases automatic.

Transportation Cost. A fixed cost is often incurred regardless of the size of the order. For instance, the cost of delivery by a truck is the same whether it is fully-loaded or half-full. There is also a pricing scheme for less than truckload delivery that includes fixed component that is independent of the quantity being shipped and a variable component that increases with the quantity being shipped. The fixed component should be included in the order cost.

Receiving Cost. Any administration work such as purchase order matching and any effort associated with updating inventory records is considered part of the receiving cost. They are incurred regardless of the size of the order.

Other Costs. All costs incurred for each order regardless of the volume of that order should be included in the order cost.

G. INVENTORY MODELS

In dealing with the control of inventory, the most important decisions to be made are how much of the product needs to be ordered and when the order should be made (Balakrishnan, Render, & Stair, 2006, p. 12-5). There are several inventory models that

provide answers to the two fundamental questions that are often posed to supply chain managers. For a more detailed discussion of the different inventory models, refer to the work of Balakrishnan, Render, & Stair (2006). Unfortunately, none of the traditional inventory models capture the inventory management need of R-RAM warehouse. Take the case of the classic Economic Order Quantity (EOQ) model that strives to determine the specific point “R,” at which an order will be placed and the size of that order, “Q,” based on the following assumptions:

- Demand is known and constant.
- The lead time—the time between the placement of the order and the receipt of the order—is known and constant.
- The receipt of inventory is instantaneous. In other words, the inventory from an order arrives in one batch, at one point in time.
- Quantity discounts are not possible.
- The only variable costs are the ordering cost and the cost of holding or storing inventory over time.
- If orders are placed at the right time, stockouts and shortages can be completely avoided.

The following equation represents the cost structure in EOQ model:

$$TC = DC + \frac{D}{Q}S + \frac{Q}{2}H$$

Where:

TC=Total annual cost

D=Demand (annual)

C=Cost per unit

Q=Quantity to be ordered

S=Setup cost

R=Reorder Point

L=Lead Time

H=Annual holding and storage cost per unit of average inventory

By using calculus, the optimal quantity can be derived and expressed as follows:

$$Q_{opt} = \sqrt{\frac{2DS}{H}}$$

With constant demand and lead-time, no safety stock is needed, thus reorder point “R” is expressed as:

$$R = \bar{d} L$$

Where:

\bar{d} =average daily demand (constant)

L=lead time in days (constant)

However, the R-RAM situation dictates that the lead time and demand are not constant. This necessitates safety stock in order to offset the inherent variability brought about by the two variables mentioned. A certain level of protection must be in place to prevent stock outs. In essence, safety stock is defined as the amount of inventory needed in addition to the expected demand (Apte et al., 2006, p. 135). The concept of safety stock assumes that supplies are readily available once it was determined. However, in the case of R-RAM, supplies arrive at the warehouse in random fashion. Again, this situation renders the safety stock concept unusable.

H. INVENTORY MANAGEMENT IN CLOSEDLOOP SUPPLY CHAINS

Recent developments in the management of the supply chain have redrawn the traditional picture of inventory management. It used to be a simple linear structure wherein goods were being transferred from the manufacturer to the end-users through the wholesalers and retailers. However, it is being replaced by a more complex structure that incorporates the upstream flow of goods in the traditional supply chain. The integration of the upstream flow of goods in the overall supply chain concept is now being called “closed loop supply chains” (REVLOG, 2008).

Consequently, the traditional inventory management models cannot be applied in managing the inventory in the reverse channel primarily due to the randomness of the arrival of supplies. (Theirry Salomon, Nunen, & Van Wassenhove, 1995, p. 118). Fleischmann and Minner (2003) acknowledged the complexity in managing the closed loop supply chain brought about by the flowing of additional supplies coming from overstock returns, service parts, and reusable packaging (2003, p. 116). As a result, the inventory management of the closed loop supply chain necessitates the need to find models that exploit the value potential of the recoverable resources that flow in the system. Fleischmann and Minner (2003) also detail an explanation of the different quantitative approaches to managing inventories in the closed loop supply chain (p. 116).

Although the most simplistic way to deal with this complication is to totally ignore it until the product returns arrived, such an action runs the risk of excessive stock levels in the case of high return volumes. Another alternative is to cancel returns against some of the demand, which is called “netting.” This practice tends to overestimate the resulting service level by implicitly assuming that the return coincides with the demand, which is not the case (p. 118).

I. MULTI-PERIOD, SINGLE-ECHELON MODEL IN CLOSED-LOOP SUPPLY CHAIN

The model that is nearly applicable to our work among those presented by Fleischmann and Minner (2003) is the multi-period, single-echelon model that involves repeated replenishment during the sales horizon—period of operation—and which inventory may be carried over from one period to another. A single stock point is also involved, which results in product returns joining the serviceable inventory immediately. This process assumes that the returns are reusable and in the same quality when they enter the forward supply chain.

According to Zheng and Federgruen (1997), this model is similar to conventional single-item stochastic inventory control models where an (s, S) order policy is known to be optimal under general conditions, if any unmet demand is backordered (p. 654). However, the addition of supplies coming from the reverse channel may complicate the

situation considerably because such actions can affect the inventory level at multiple points. Thus, it is no longer accurate to model the problem as a single-dimensional Markov chain. However, this can be addressed by the assumptions made by Fleischmann and Kuik (2003) that show an (s, S) order policy remains average cost optimal under the following conditions:

- Demand and returns are independent.
- The lead time of a potential recovery process does not exceed the regular replenishment lead time.
- Product returns may not be disposed (pp. 25-37).

However, R-RAM can dispose supplies subject to its changing business rules. As a result, the model may not accurately determine the optimal inventory level of our closed loop supply chain. Due to the uniqueness of the R-RAM closed loop supply chain and the limited literature available on Reverse Logistics inventory management model, the authors are basing their inventory approach on their own heuristics.

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III. METHODOLOGY

A. INTRODUCTION

A literature review of textbooks on inventory management, DoD and Navy policies on supply chain management and procedures, Internet-based materials and other library information were conducted to understand the concept of Reverse Logistics. From these reviews, we formulated our primary research questions. This section will identify the step-by-step process of the methodology that will be used to answer the research questions.

B. METHOD

The entire line item inventory database of the San Diego R-RAM warehouse was downloaded from the LAWSON inventory management database. A PLSQL¹⁰ package, containing a series of PLSQL procedures and functions, was developed. The actual process was executed in a batch mode by Ship Class. The job query was then scheduled using the Oracle scheduler. Primary data was compiled and analyzed using the steps discussed below.

- The NIINs were loaded into an Oracle table.
- Using these NIINs, all the APLs were obtained from the Oracle version of the Weapons Systems File (WSF). This Oracle database is referred to as the Midtier or the Tier 2. The database is owned by NAVSISA. The Midtier is updated from the WSF on a daily basis—making it very close to “real time.”
- Using the APLs obtained from the Midtier, we compared the APLs to the current ship's configuration for active ships in the 10 ship-classes. The active ships were determined from the Naval Vessel Registry. The current configuration was obtained from CDMD-OA (Configuration Data Managers Database—Open Architecture). CDMD-OA tracks the status and maintenance of naval equipment and their related logistics items (drawings, manuals, etc.) on ships and naval activities around the world. CDMD-OA is an Oracle database that is managed by Naval Sea Logistics Center.

¹⁰ PL/SQL (Procedural Language/Structured Query Language) is Oracle Corporation's proprietary procedural extension to the SQL database language, used in the Oracle database.

- When an APL was found in the current configuration of one of the ship classes specified, it was matched against the list of NIINs. If there was a match, then it was considered a “hit” and annotated in the excel file with an “X.”

The 10 classes of ships we analyzed for COSAL applicability include FFG, DD, DDG, CG, LSD, LPD, PC, MCM, LHA, and LHD. Some of these classes are no longer in commission or are being phased out. We analyzed the results of the batch queries to determine:

- How many parts in the R-RAM inventory have an application to a ship in the active Naval Registry?
- How many parts no longer have any application to current and former ships in the registry for disposal via the DRMO¹¹ program?
- How many parts have an application to ships formerly in the active roster and are now in the service of foreign navies? This will assist our analysis by providing an alternative method of disposal of the “dead” stock or obsolete parts in the R-RAM warehouse through the Foreign Military Sales (FMS) program.¹²

C. OBJECTIVE

The results of the PLSQL queries will enable us to answer our primary research questions on how to increase throughput while simultaneously minimizing inventory and operating expense (inventory holding costs).

- If a line item in the R-RAM inventory has an application to one or more class of ship in the active US Navy fleet, it will be a candidate to remain in the inventory.
- If a line item is only common to a DD or FF, it will be a candidate to be removed as obsolete stock. The DD and FF ship-classes are no longer in service in the US Navy. Many of these two classes of ships have been sold and are now in the active service of foreign navies. These items are good candidates for disposal via the FMS program to the Allied nations.

¹¹ Defense Reutilization and Marketing Office disposes of excess property received from the military services.

¹² The US Department of Defense's Foreign Military Sales program facilitates sales of US arms, defense equipment, defense services, and military training to foreign governments. The purchaser does not deal directly with the defense contractor; instead, the Defense Security Cooperation Agency serves as an intermediary, usually handling procurement, logistics and delivery and often providing product support and training.

- If a line item has no application to any active or former naval ships due to obsolescence then it will be a candidate for disposal via DRMS.

Periodic reduction in held inventory through disposal of obsolete and excess spares will reduce warehouse footprint, reduce holding costs, and improve inventory management.

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IV. ANALYSIS OF R-RAM SD INVENTORY

A. OVERVIEW

An inventory is an idle resource that possesses economic value (Monks, 1977, p. 325). The beginning FY08 warehouse inventory at the San Diego warehouse is over 25,000 line items valued in excess of \$289 million (Hirst, 2007). Figure 2 illustrates the breakdown of these spares. The breakdowns include \$157 million for depot level repairable parts, \$92 million for maintenance assist modules and \$40 million in consumables.



Figure 2. R-RAM SD Spares Inventory

This “gold pile” has resulted in huge savings for CNSF afloat units as requisitions were filled free of charge. Changes in the order fulfillment process at FISC ensured that R-RAM warehouses are first screened for any free-issue assets before the normal supply chain fills any requisition. Improvements in inventory database management and implementation of Total Asset Visibility (TAV) through the employment of the web-enabled R-RAM system have resulted in an increase in the volume of business for the warehouses. And with this increase in the number of requisitions filled, there is an increase in cost avoidance for the requisitioning Afloat unit. Figure 3 shows that for the periods FY05 to FY08, the cost avoidance was \$98.9 to CNSF’s O&M budget, while incurring a direct labor cost of \$2.6 million. Even if the warehousing and inventory holding costs are factored in, it is still a substantial return on investment, given extant fiscal restraints.

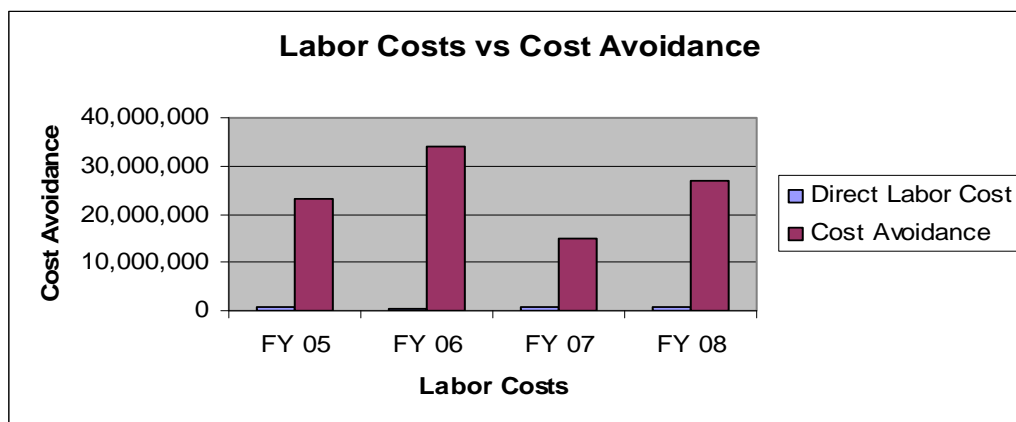


Figure 3. R-RAM SD Labor Cost vs. Cost Avoidance

Even with an increasing volume of requisitions ordered and filled by R-RAM SD, the warehouse still carries a huge stockpile of assets. Ship decommissioning and CNSF-directed offload of excess material aboard surface ships (REMOVE program) ensures that the warehouse will continually receive spares for warehousing. In the last five fiscal years, the inventory in the warehouse showed an increasing trend. This inventory will continue to rise as more ships are nearing the end of their useful life, and weapons systems are upgraded or come into obsolescence. Figure 4 shows an increasing trend for spares received for storage at R-RAM SD.

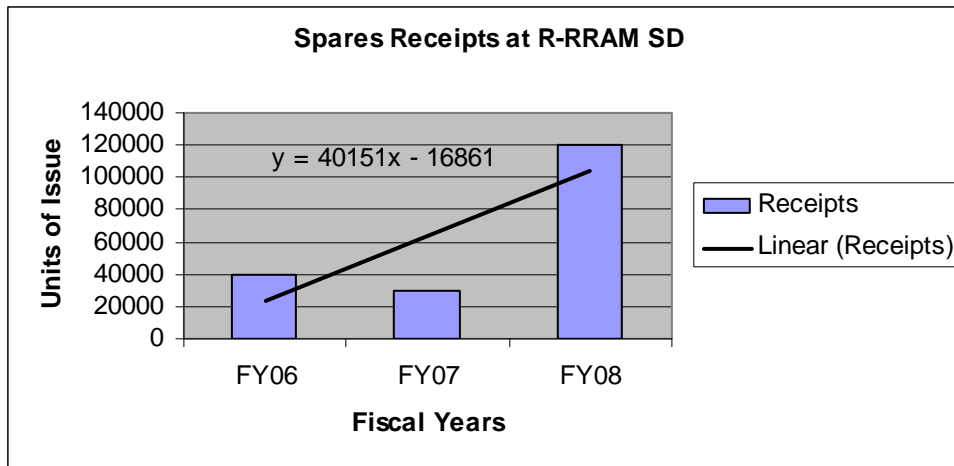


Figure 4. Spares inventory received by R-RAM SD

B. BREAKDOWN OF CURRENT INVENTORY

The goal of this report is to increase throughput, determine dead stock due to obsolescence, and reduce inventory footprint by exploring ways to dispose of obsolete and dead stock. We began our analysis of the results of the PLSQL data queries by using EXCEL's sort and "COUNTA" functions to determine the number of ship applications per NIIN. Table 1 shows an example of a result of a PLSQL query while Figure 5 shows the following breakdown of ship applications for each NIIN for the database as of April 11, 2008.

Item Description	Stock On Hand	Standard Price	CG	DDG	DD	FF	FFG	LHA	LHD	LPD	Hcount
16 CHANNEL A,D-D,A	1	10,696.00	X	X	X						3
ADAPTER CONNECTOR	1	16.52	X	X				X	X		4
ADAPTER CONNECTOR	1	16.52	X	X				X	X		4
AMPLIFIER ASSEMBLY,	2	6,081.00									0
AMPLIFIER DEFLECTIO	12	3,401.00	X	X	X		X	X	X		6
AMPLIFIER SUBASSEMB	1	6,569.00	X	X							2
AMPLIFIER SUBASSEMBLY	1	1,336.00	X	X	X		X	X			5
AMPLIFIER SUBASSEMBLY	8	3,114.00	X	X	X						3
AMPLIFIER SUBASSEMBLY	4	14,721.51		X							1
AMPLIFIER SUBASSEMBLY	6	2,473.00	X	X	X		X	X	X		6

Table 1. An example of a PLSQL query result

Inventory Breakdown

	NIIN Range	Depth	CG	DDG	DD	FF	FFG	PC	LHA	LHD	LPD	Obsolete
MAM	5814	33983	4,162.00	3784	3830	882	2487	1	2301	2144	703	372
DLR + 9 COG	27498	133196	12,157.00	13065	13032	7482	10151	997	7850	9598	9981	6469

- Maintenance Assist Modules (MAMs)
5,814 NIINs/ Valued at \$96M
- Depot Level Repairables (DLR) + 9 COG
27,498 NIINs/ Valued at \$218M

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Figure 5. R-RAM SD Inventory Breakdown

C. OBSOLETE NIINS

Spare parts that did not register a current ship application were considered as obsolete. Obsolescence could be due to weapons systems upgrade or that they were no longer installed aboard a ship platform. Figure 6 shows 6,841 line items valued at \$31 million that were deemed obsolete. These spares are good candidates for disposal through the DRMS program.

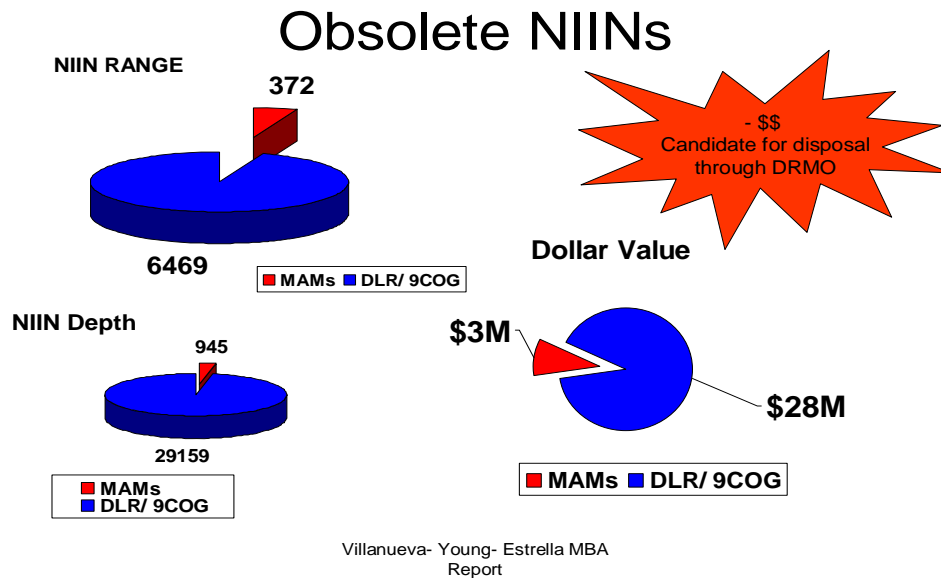


Figure 6. Obsolete NIINs

D. SHIP CLASS-DESTROYERS (DD)

We identified spare parts that have application only to the Destroyer class of ships (DD). The DD-class is no longer in active service of the United States Navy. However, a number of our allies still maintain this ship class in their naval order of battle. Continuing to hold these parts in the R-RAM SD warehouse provides no value to CNSF since the probability of having a demand is zero. Moreover, inventory-holding cost is incurred without benefit in return. Figure 7 shows that there are 543 line items valued at

\$4.6 million that can be considered as dead stock. These spares can be sold to foreign navies subject to the rules of the Foreign Military Sales program.

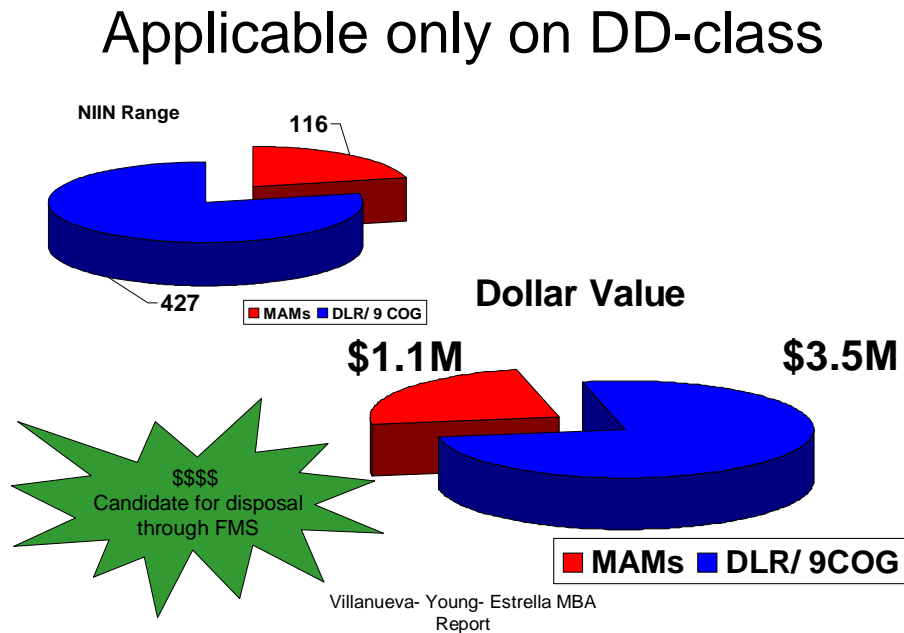


Figure 7. NIINs Applicable to DD-class only

E. SHIP CLASS-FAST FRIGATE (FF)

We also identified spare parts that have application only to the Fast Frigate class of ships (FF). The FF-class is no longer in active service of the United States Navy. However, a number of our allies still maintain this ship class in their naval registry. As in the DD inventory, continuing to hold these parts in the R-RAM SD warehouse provides no value to CNSF due to the zero probability of demand. Figure 8 shows that there are 372 line items, valued at \$2.2 million that can be considered as dead stock. These spares can be sold to foreign navies subject to the rules of the Foreign Military Sales program.

Applicable only on FF-class

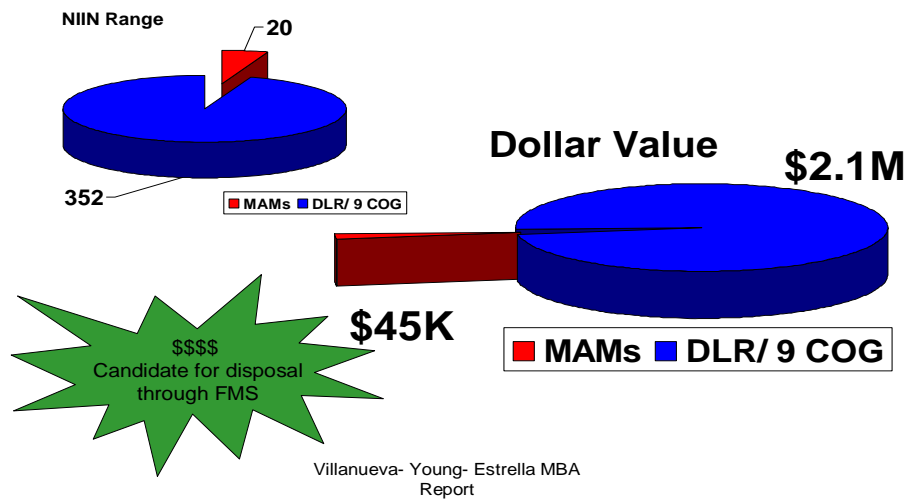


Figure 8. NIINs Applicable to FF-class only

Our PLSQL query also resulted in the identification of 37 line items valued at over \$350,000 that can be considered dead stock, as shown by Figure 9. These spares can be sold to foreign navies subject to the rules of the Foreign Military Sales program.

Applicable only on both DD and FF-class

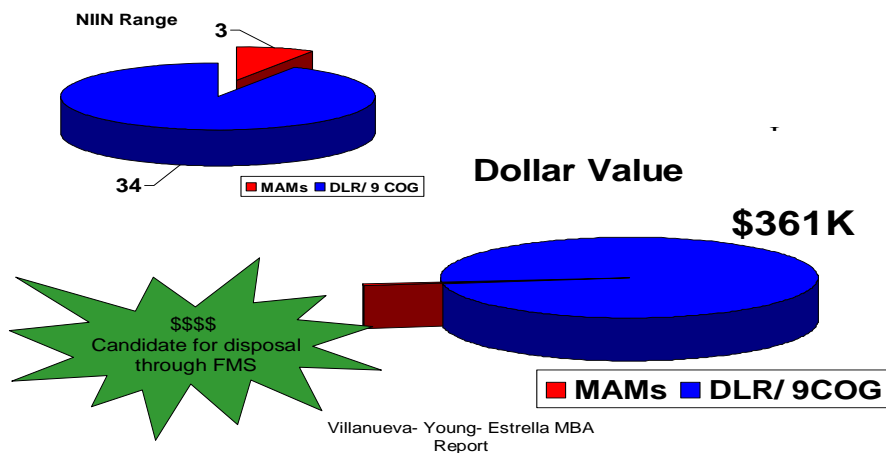


Figure 9. NIINs Applicable to DD-class and FF-class only

F. INVENTORY MANAGEMENT BUSINESS RULES

Prior to May 2007, receipt and offload of ship excess repair parts to the warehouse were subject to the following inventory management control criteria:

- Offload material from non-SAC 207(BP-28) decommissioning ships or ships with TYCOM authority to offload material that is no longer applicable to an APL
- The criterion for induction into R-RAM inventory is “A” condition HM&E/MAM/DLR extended money value (EMV) of less than \$100
- No classified material spares
- No hazardous material/ waste
- Dollar-(value) based inventory

In addition, whenever a ship is decommissioned, all spares onboard were offloaded to R-RAM, regardless of whether the spares are obsolete or have no demand. These obsolete and no-demand parts increased inventory and operational expense (holding costs), while not necessarily increasing throughput. Furthermore, these parts have contributed to the growth of the “gold pile,” without providing any real value to CNSF.

In its efforts to improve inventory control, CNSF N41 redefined the inventory criteria to Demand Base vice Value Base. DRS&T, the contractor, established and implemented these tailored business rules. The new rules went into effect June 2007. The new criteria for receipt and offload of spares are the following:

- Material must be active Navy items
- Material will be retained in R-RAM inventory in a quantity up to four (4) times the average monthly demand (AMD) of the Navy’s Global Demand File (GDF)
- No classified material
- No hazardous material
- All Maintenance Assist Modules (MAMs) will be considered serviceable, A-condition unless cracked, bent or broken
- All Depot Level Repairables (DLRs) will be packed per the NAVSUP Publication P700

These changes in inventory criteria resulted in an almost 50% reduction in cost avoidance from FY06 to FY07. However, it should be noted that FY07 cost avoidance values include both the savings under the “old” and “new” business rules. CNSF N41 and the contractor attribute the reduction to a change in business rules, rather than a decrease in demand. We believed that this reduction is not due to the change in business rules, but rather, due to a decrease in demand. If anything, the effect of a demand-based inventory system would be an increase in issues (requisitions filled) because the spares that will be inducted into the R-RAM system have sufficient demand, thus increasing the total cost avoidance. The effects of the changes will be in the range and depth of NIINs that would be carried in the R-RAM inventory. The cost avoidance for FY08 showed that the savings were more or less in line with previous fiscal years.

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V. RECOMMENDATIONS AND CONCLUSIONS

A. INVENTORY

We recommend reducing inventory footprint and inventory holding costs by disposing dead stock due to obsolescence. One problem of inventory management is how to balance the advantages of having inventories to satisfy demand and the inventory holding costs. Our analysis of FY08 beginning inventory indicates that 6,841 line items valued at \$31 million can be safely eliminated from stock (27% reduction in footprint).

- We recommend the disposal of 6,841 line items valued at \$31 million through the Defense Reutilization Marketing Service (DRMS). These parts are obsolete. CNSF will save overhead and carrying costs.
- We recommend the disposal of 952 line items valued at \$7.1 million through the Foreign Military Sales program. Sale of these assets would be subject to DoD and DoN policies. We recommend CNSF pursue this approach and possibly receive some remuneration from sales, vice disposal through DRMS.
- We recognized that since the publication of this report the R-RAM inventory have changed. Some of the parts we have identified as obsolete and no-demand might have been turned into DRMO by now. However, our methodology still applies to current and future inventory at the San Diego warehouse and at other R-RAM sites.
- In the course of our research of the R-RAM inventory, we determined that the typical industry inventory management controls and models are not applicable. Inventory controls such as economic order quantity (EOQ) and safety stock, to name a few, cannot be applied because of very high levels of supply and demand uncertainty, military-unique parts that are no longer in production but may still have demand in the future, and cost structure of the parts (received and issued for free).

We recognized the current contractor's proactive efforts in reducing inventory footprint by changing stocking criteria and by regular DRMS disposal. On the question of what is the right stock level, we recommend balancing the ideal stock level to meet uncertain demand from ships with the inventory holding cost vis-à-vis the cost of stock-out and the cost of producing or procuring a new item. Because regular inventory control theories such as the economic order quantity are irrelevant in the R-RAM concept, the decision on the depth for any range of inventory is a quantitative and qualitative

decision by N41, based on an acceptable service level, demand history and trade-offs. We recommend a study be undertaken in the future to determine the ideal stock level.

In addition, we recommend increasing the frequency of generating ZI217-BGJ (parts turned-in to DRMO transactions). This will aid in reducing inventory footprint by the regular disposal of dead stock and obsolete items.

While there is a tangible gain in doing FTR/FTE (FY08 credits to CNSF was \$1.4 million), it should be noted that with the new demand-based inventory system, the spares—technically—have sufficient demand. Selling it to ICP at less than the standard price, puts the operating forces at a financial disadvantage by having to procure the part at standard price from ICP, whereas before it would have been free from R-RAM. We recommend selective use of FTR/FTE/MTIS turn-ins. Spares with on hand quantities in excess of established depth are good candidates for FTR/FTE.

B. BUSINESS RULES

The results of cost avoidance for the period July to September of FY07 and FY08 under the new business rules seemed to indicate no noticeable change when compared to results under the old business rules. A couple more years of operating under these new rules would provide sufficient data for analysis. We believe that the change from value-based inventory to demand-based system is the right step in inventory management. The change will ensure that only parts with active demand will be stored at the warehouse. It is a transformational approach to the positioning/use of maritime spares that optimizes spares investment and maintains afloat supply readiness with acceptable risk.

C. WAREHOUSE MANAGEMENT

There is an ongoing discussion whether the warehouse is within CNSF N41's core competency. We believe that maintaining the warehouse fits within N41's role of organizing, training, and equipping operating forces. The cost avoidance and the resulting huge savings in the O & M account, is just one value-added benefit to CNSF, given extant fiscal restraints. Another, more important value-added is logistics readiness and weapon system operational availability (Ao). The lead-time reduction (lower

ACWT) from RFI stocks at the warehouses contribute to lower maintenance down time (MDT). The ability to quickly fill customer requisitions from local assets contributes to high operational readiness. We recommend CNSF retain this capability.

In addition, we recommend further study on the merits of physical consolidation of the warehouses. Consolidation will further reduce operating expenses, risks pooling, streamline operations, and allow for negotiations for one global contract. Consolidating physical assets into the major fleet-concentration areas where a majority of requisitions originate from, such as San Diego and Norfolk, should be explored. However such consolidation should be balanced with the expected increase in transportation costs, as well as a possible reduction in service level (ACWT) in areas losing a R-RAM site.

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